Instruction Manual 23Jc

for the

AC High-Pot Tester

Catalog No. 230XXX(-X) Series

MP MASTER
MA35461

James G. Biddle Co.

BLUE BELL, PA. 19422

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HIGH-VOLTAGE EQUIPMENT

PLEASE READ CAREFULLY BEFORE OPERATING

Safety is the responsibility of the user

APARATO DE ALTO VOLTAJE

SIRVANSE LEER ESTE LIBRO CON CUIDADO ANTES DE OPERARLO

La seguridad es la responsabilidad del operador

JAMES G. BIDDLE CO.
Blue Bell, Pa. 19422

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Figure 1: The Biddle AC High Pot Test Set.

Section A

INTRODUCTION

GENERAL

This instruction manual covers the operation and maintenance of Biddle portable High-Pot Testers. Because all Models are modified versions of the Model 305, this manual is applicable to all. Model numbers describe input and output characteristics as follows:

1st digit = output voltage (kV)
2nd & 3rd digit = short circuit current (mA)

Without dash number = 120V, 60 Hz
Followed by -1 = 240V, 60 Hz
Followed by -2 = 120V, 60 Hz with reset pushbutton.
Followed by -3 = 240V, 60 Hz with reset pushbutton
Followed by -4 = 120V, 60 Hz with test pushbutton.
Followed by -5 = 240V, 60 Hz with test pushbutton.
Followed by -6 = 120V, 60 Hz with reset and test pushbuttons.
Followed by -7 = 240V, 60 Hz with reset and test pushbuttons.

Note: 240V models will operate at 50 Hz; however, the maximum output voltage will be approximately 150V lower and short circuit current approximately 1 mA higher than when operated at 60 Hz.

Example: Model 305-1 = 3000V output, 5 mA short circuit current, 240V, 60 Hz input

This compact, self-contained unit is a high-voltage low-energy source for testing the dielectric strength of electrical insulation. The test set has been designed to simplify the test procedure and to eliminate or minimize hazards to the operator and to the apparatus under test. This instrument is equipped with all features currently required for UL approved withstand tests. (See Section H.)

The instructions and suggestions provided in this manual anticipate the normal use of the high-pot tester for testing electrical insulation systems on such equipment as motors, transformers, and all line-operated electrical appliances. High-pot testing is a valuable method of detecting assembly flaws (such as stray wire strands, etc.) and defects in marginally sound insulation which can present a hazard to the user or cause product failure during normal use.

INTRODUCTION

A MESSAGE ABOUT ELECTRICAL SAFETY

For operator safety and to assure OSHA approval, the high-pot tester has been designed to meet all applicable requirements of ANSI C39.5 - 1974 "Safety Requirements for Electrical and Electronic Measuring and Controlling Instrumentation." This standard is the only existing national consensus standard in this field, having been approved by such agencies as Underwriters Laboratories, Inc., National Bureau of Standards, General Service Administration, U.S. Navy Ship Engineering Center, Instrument Society of America, IEEE, and many others. We believe that this standard is the best available formal design guide for instrument safety.

Here are some of the special safety features of the high-pot tester:

1. Output short-circuit current limited to 4.2 mA nominal (5.0 maximum by 100% factory test) by the built-in reactance of the high-voltage transformer itself. This current level, while adequate for most tests, is well below the "let-go" range (of about 10-20 mA for adult men) established by electrical safety research. (The short circuit current limit is increased to about 6.2 mA by operation on 50 Hz supply.)

2. A completely insulating case surrounding an internal grounded chassis and safety shield. This is a unique combination of both of the recognized methods of protection against electric shock due to internal insulation failure.

3. An interlock which deenergizes the output whenever a test failure is detected and lights a CAUTION HIGH VOLTAGE lamp when the output is energized.

4. A "zero-start" system which requires that the voltage control be set at zero before the output can be energized. (Except on models having "Test" or "Reset" buttons).

5. Output leads firmly clamped into the set, yet replaceable if they become damaged. When stored in the case, the leads are protected from damage when not in use.

6. Abbreviated version of operating procedures conveniently displayed on lid panel. The full instruction manual fits in the lid compartment.

INTRODUCTION

To further ensure a safe design, we have made formal safety reviews of the initial design and any subsequent changes. This procedure is followed for all new Biddle instruments and covers areas not included in the ANSI standard. Regardless of these efforts, however, we do not believe it is possible to eliminate all hazards from electrical test equipment. For this reason, we make every effort to point out in the instruction manual the proper procedures and precautions to be followed by the user in operating the instrument and to mark the instrument itself with precautionary warnings where appropriate.

We have endeavored to do our part. For your part, please read, understand, and follow the procedures and precautions outlined in Section B and throughout this manual.

Section B

SAFETY PRECAUTIONS

SAFETY IS THE RESPONSIBILITY OF THE USER.

LA SEGURIDAD ES LA RESPONSABILIDAD DEL OPERADOR.

Although this test set has better protection against electric shock hazard than the typical home appliance, it must be treated as a source of possibly dangerous electric energy. The output current, in the worst situation, may be harmful to persons in poor health or may cause secondary injuries such as those which may result from falling.

To insure safe use of the set, do not treat it casually. Read and understand these Instructions, and follow the safety rules given, paying special attention to the following areas:

1. Provide a safe area for use of the set.

2. Operate the set according to these instructions.

3. Maintain the set, with a regular maintenance program.

4. When persons trained in high voltage testing use the set, they should read and understand this entire Instruction Manual before using for the first time.

5. When unskilled personnel use the set, they should be trained in a fixed operating routine for each test setup, and supervised by a person who fully understands the use of the set.

CAUTION!

The use of non-standard test leads, or test procedures other than those described in this manual, may increase shock hazard. Extra operator care is required in such cases.

Section C

RECEIVING INSTRUCTIONS

When your Biddle instrument arrives, check the equipment received against the packing list to ensure that all materials are present. Notify James G. Biddle Co., Blue Bell, Pa., of any shortage of materials.

Examine the instrument for damage received in transit. If any damage is discovered, file a claim with the carrier at once and notify James G. Biddle Co., or its nearest authorized sales representative, giving a detailed description of the damage observed.

This instrument has been thoroughly tested and inspected to meet rigid inspection specifications before being shipped. It is ready for use. To confirm that the tester is in good operating condition, see Section F.

Section D

SPECIFICATIONS

Input:	120V, 60 Hz, 25 VA max. (Cat. Nos. 230305, and 230405). 240V, 60 Hz, 40 VA max. (Cat. Nos. 230305-1, and 230405-1).
Output:	
Voltage	Calibrated 0 - 3000V (4000V) ac, adjustable, low side grounded, essentially sinusoidal.
Open-Circuit Voltage (maximum)	3300 V (Cat. Nos. 230305, 230305-1). 4300 V (Cat. Nos. 230405, 230405-1).
Short-Circuit Current	5 mA Maximum (approx. 6.2 mA on 50 Hz).
Capacitive Load	Maximum: 7500 pF at 3000V 10,000 pF at 1500V Resonance with internal inductance: at C = 3100 pF.
Test Voltage Control:	Manual, by adjustable autotransformer with zero-start interlock.
Voltmeter:	4-1/2" taut band, 0-3000V rms. Accuracy: 2% Full Scale, field adjustable.
Failure Detection:	Two modes selectable by screwdriver-operated switch: Breakdown only: Failure signal produced by arcing. Leakage or Breakdown: Failure signal produced by arcing or by leakage current. Leakage trip level adjustable between approximately 0.3 mA and 4.2 mA.
Failure Interlock:	Failure detection trips high voltage off and keeps it off until manually reset by turning voltage control to zero position. Models with "Reset" pushbutton may be reset without moving voltage control.

Section D (Continued)

SPECIFICATIONS

Indicators:	
POWER Lamp	Indicates supply voltage is "ON".
CAUTION-HIGH VOLTAGE Lamp.	Indicates that high-voltage output is energized.
FAILURE Lamp	Indicates that a failure has occurred.
Audible Alarm	Audible signal sounds when FAILURE lamp is lit.
Power Switch:	Two-pole, in 120-volt line.
Line Fuses:	One 2.0 A AGC (Cat. Nos. 230305, 230405). Three 2.0 A AGC (Cat. Nos. 230305-1, 230405-1)
Input Power Cord:	Attached, 8 ft. (2.4 meters), 3-wire, with molded plug, UL listed Type SJ.
Output Lead:	Attached, 3 ft. (1 meter), red, field replaceable. Hand probe termination accepts bulldog clip (supplied) when desired. Assembly proof-tested to 15kV dc.
Ground Lead:	Attached, 3 ft. (1 meter), black with insulated bulldog clip, field replaceable. Assembly proof-tested to 15 kV dc.
Construction:	Molded flame-retardant case with carrying handle and removable hinged cover. Interior chassis grounded and exterior surfaces all insulation, tested to 15 kV.
Dimensions:	9 x 7-1/2 x 7-1/2 inches high (23 x 19 x 19 cm).
Weight:	10 lbs. (4.2 kg)

Section E

DESCRIPTION

GENERAL

The portable high-pot tester includes a variable high-voltage source, an adjustable leakage current level detector, a breakdown or flashover detector, and visual and audible failure indicators. The circuitry is simple and utilizes highly reliable passive components for long, trouble-free service.

The lid of the tester case is fitted with a covered compartment which holds the power cord, test leads, and instruction manual. Abbreviated operating instructions are given on the compartment cover.

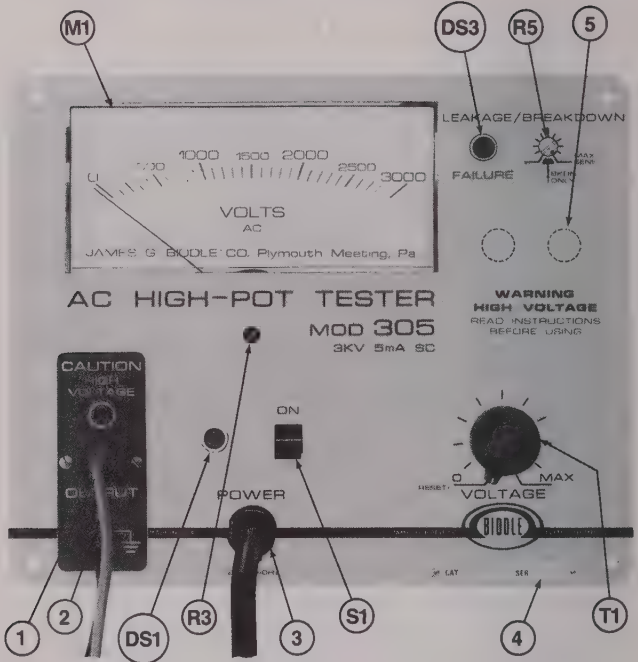
To protect the operator from shock hazard, a unique triple protection is provided between the operator and the internal voltages of the test set. In addition to the normal insulation between conducting parts and metal frame, a second barrier of insulation surrounds all metal parts. The metal frame itself is grounded by the third wire of the supply cord, so that a shock hazard exists only if the ground fails and two layers of insulation break down. (The triple protection does not extend to the test leads).

The high-voltage transformer is of the high-reactance current limiting type. As the load current approaches the limiting value, the output voltage drops rapidly, until at short circuit (zero output voltage) a current of 4.2 mA is reached. This feature allows the output to be short-circuited without causing damage to the transformer or the equipment being tested. More important, it protects the user from shock hazard.

240V 60 Hz operation is enabled by adding an autotransformer to the basic set as shown in Figure 8.

CONTROLS AND CONNECTORS

The location of controls and connectors are illustrated in Figure 2. All knobs and other exposed hardware are fully insulated. The functions of the controls are described below.



M1 Output Meter
R3 Meter Zero Adjust
DS3 Failure Indicator
R5 Leakage/Breakdown Control
DS2 High Voltage Indicator
1 High Voltage Output Cable
2 Ground Cable
DS1 Power ON Indicator
S1 Power Switch
3 AC Power Cord
T1 Voltage Control
4 Serial Number
5 Pushbutton Location for "TEST" and "RESET" options.

Figure 2: Controls and Connectors.

DESCRIPTION

VOLTAGE CONTROL

This knob serves as voltage control and also as a reset and zero-start control. When the power switch is first moved to the ON position, or after a failure has occurred, no output voltage will be present at the output terminals of the tester until the voltage control has been rotated to the zero or RESET position.

LEAKAGE/BREAKDOWN CONTROL

Selects the modes of failure detection. In the Breakdown Only position the failure signal is produced only by arcing. In other positions, the failure signal is produced by either arcing or by line frequency current ("Leakage") which is caused by capacitance or resistance of the item being tested. The leakage trip level is continuously variable between approximately 0.3 and 4.2 mA. The reference scale which surrounds the shaft of the control is useful for adjusting the test level to previously established leakage settings for specific items. The setting is indicated by the dot index on the shaft. The control clearly indicates to the operator both the operating mode and the leakage reference setting; but since it is screwdriver-operated, it is not subject to accidental setting changes.

INDICATORS

The POWER ON lamp indicates that the set is on. The CAUTION HIGH VOLTAGE lamp lights when the high-voltage output is energized. When a tripout occurs the FAILURE lamp lights and an audible signal (buzzer) sounds. The tripout also deenergizes the output, causing the HIGH VOLTAGE lamp to go out.

OPTIONAL FEATURES

Modified High-Pot Testers differ from the Model 305 in one or more of the following ways: 240V 60 Hz input; 4000V output; a reset button which allows test voltage to be restored after failure, without moving the voltage control; a "Test" pushbutton which permits output voltage only when depressed; test leads with retractable probe; test leads of different length.

Section F

OPERATION

Test Area

For all work with the tester, arrange a test area as follows:

1. Use a dry test area with operator and all equipment shielded from traffic and casual intruders.

2. Locate the tester within three feet of the equipment being tested, and within eight feet of a 3-wire (grounded) power supply outlet and within ten feet of a separate earth ground connection.

3. Place the appliance under test out of the operator's normal reach.

Safety Precautions: Follow the safety precautions of Section B.

Safety and Function Check

Follow the procedure shown in Table I before conducting tests, to confirm that the tester is operating properly and safely. Make the checks at each change of shift, operator, or item being tested, and more frequently as needed.

Always make the ground test (second column) when setting up in a new location.

Tester Setup

Section G explains what tests can be made and how to set up the trip levels on the tester. Figure 3 shows a typical hookup.

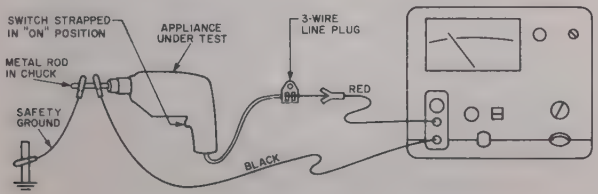


Figure 3: Typical Test Setup.

OPERATION

TABLE 1: SAFETY AND FUNCTION CHECK

Correct test results are shown inside blocks. If these results do not occur, trouble shoot the tester and the test setup.

To Test: Zero Start, Signals, Reset, Output.

Setup:
Power off.
VOLTAGE knob at one mark above 0.
Test leads open (clip to lid).

First Test:
Power On.

Power lamp on. FAILURE lamp on. Buzzer sounds. Voltmeter at zero.

Second Test:
VOLTAGE knob at 0.

FAILURE lamp off. Buzzer off. HI VOLT.lamp on.

Third Test:
Raise Voltage.

At 1-2 marks below MAX on VOLT knob, meter reads 3000.

Turn VOLTAGE down.
Shut off.

To Test: Safety Ground, Leakage Trip.

Setup:
Power off.
VOLTAGE knob at 0.
Black lead open.
Red lead to ground. (Cold water pipe, etc.)
If LEAK/BKDN control is at BKDN ONLY, move it to MAX SENS.

Test:
Power On.
Slowly raise voltage.

Tripout occurs at 60-80 volts.

and
VOLTAGE knob position is as follows:

LEAK/BKDN Setting	VOLTAGE Knob Setting
MAX SENS	First Mark
Min (ccw Mark)	Ninth Mark
Intermediate	1st-9th Mark

Turn VOLTAGE down.
Shut off.
Set LEAK/BKDN to working position.

To Test: Breakdown Trip (Perform if using BKDN ONLY mode).

Setup:
Power off.
VOLTAGE knob at 0.
BKDN ONLY mode.
Red lead open.
Clip black lead to a probe (a coin will serve).

Test:
Power On.
Raise Voltage to 1000 volts.
Carefully - tap black test probe against red test tip to cause sparking.

Tripout Occurs.

Turn VOLTAGE down.
Shut Off.

Withstand Test Procedure

1. With the POWER switch off, plug in the power cord.
2. Set the VOLTAGE control to the zero (RESET) position.
3. Connect a safety ground wire between earth ground and the metal outer frame of the appliance being tested. This precaution precludes the possibility of high voltage appearing on the appliance enclosure due to unsuspected faults. Always connect this ground first and remove it last.
4. Connect the black (⏚) test lead to the same point on the appliance.
5. Connect the red (OUTPUT) lead to the electrical circuit to be tested.

> CAUTION
>
> Attach and remove the test leads only when the test set VOLTAGE control is set to zero (RESET) or when the POWER switch is off.

6. Set the power switch to ON. (If the FAILURE lamp lights and the buzzer sounds, the VOLTAGE control has not been properly set to zero.) The CAUTION HIGH VOLTAGE lamp will light, indicating that the test set is capable of producing high voltage.
7. Rotate the VOLTAGE control slowly toward the MAX setting and observe the voltmeter. Set the voltage to the desired value and maintain for the time interval required by the test being conducted.
8. During the test, be alert to these indications of failure:
   a. Buzzer sound and lighting of FAILURE lamp.
   b. Sudden voltage drop, or retarded or erratic voltmeter reading.
9. When voltage has been applied to the appliance under test for the required period of time or when a failure occurs, complete the test as follows:
   a. Rotate the VOLTAGE control to the zero (RESET) position.
   b. Set the Power switch to OFF.
   c. Remove the test leads.
   d. Remove the safety ground wire.

OPERATION

Use of Optional Features

Models with inputs and outputs which differ from the Model 305 are used according to the Operation and Application sections of this manual. An example is the Model 405-1 which is intended for use on 240V, 60 Hz lines and has a nominal output of 4 kV. Except for the line voltage requirement and higher output voltage, the Model 405-1 operates in exactly the same way as the Model 305.

A "RESET" pushbutton is included on some models in addition to the normal zero reset. At turn-on or after a failure, the output voltage can be restored by pressing this button. This by-passes the protection provided by the zero-start feature, allowing the test voltage to be set for a given test without the necessity of returning the voltage control to zero after a failure, or when the test set is turned on.

A "TEST" pushbutton is included on some models which permits output voltage only when the button is depressed. This feature allows the operator to attach the test leads to a sample when the button is not depressed, hold the test button for the required test time, and remove the leads while the test set is on.

NOTE: Some models have both the "RESET" and "TEST" buttons.

Probes with retractable guards are sometimes supplied. The combination of manual reset and retractable-guard probes is desired by some test set users to enable more rapid testing. The retractable hand probes permit the probing of a sample and are most useful when making very short tests such as the one-second at 120% of voltage permitted by some UL Standards. NOTE: When testing by the above method it is possible to have false tripout which is caused by a tiny sparking when the energized probes are applied to or withdrawn from the sample. Samples which cause a problem in this way should be tested by the regular test routine.

CAUTION!

Use of hand-held probes and reset pushbutton bypass some of the operator protections built into the standard instruments. Take special care when using instruments with these features (see Section B).

Section G

OPERATION AND APPLICATION NOTES

1. Brief Instruction for Setting the Leakage/Breakdown Control

1.1 Introduction

The Model 305 tester can test for two distinct properties of the insulation under test, namely, breakdown and excessive leakage current. Most specifications require only a breakdown test, and this procedure is very simple, as described in 1.2. Testing to a leakage specification can be more involved, as outlined in 1.3. Some items cannot be tested by the 305; this case is covered in 1.4.

The testing mode is controlled by setting the screwdriver adjustable LEAKAGE/BREAKDOWN (L/B) control on the instrument panel.

Further background is given in sub-sections 2 through 5.

1.2 Breakdown Testing

Always try to test with the L/B control set at MAX SENS. The control is set in this position when shipped from the factory.

Large test items having high capacitance may cause trip-out even when there is no breakdown. If you suspect this, reduce the sensitivity by turning the L/B control counter-clockwise. If the test is successful (voltmeter steady and no trip) at any setting of the L/B control, the item under test has passed the breakdown test.

Always set the L/B control at the most sensitive (CW) setting that avoids nuisance trips. This insures the best test and the maximum protection for both the operator and the item under test.

> CAUTION: If the test must be made with the L/B control fully CCW (switched into the BKDN ONLY position) take special care not to touch any part of the item under test.

1.3 Leakage Current Testing

If your test specification calls for a leakage current test as well as a breakdown test (this is rare) you must set the L/B control to a pre-determined setting and reject all items for which:

a. the specified voltage cannot be reached, or
b. the set trips out.

Section 5 explains how to establish the L/B control setting. Make sure your specification calls for a high-voltage leakage current test; this is often confused with the operating voltage leakage rating, which is a much more common requirement. (See 2.1)

1.4 Items Which Cannot be Tested by the Model 305.

The Model 305 cannot make tests on items whose capacitance is too high. High capacitance occurs when the item under test is very large or when the item actually includes a capacitor (sometimes provided to remove radio-frequency interference). See sub-section 3.

2. Properties of Insulation

2.1 Leakage Current

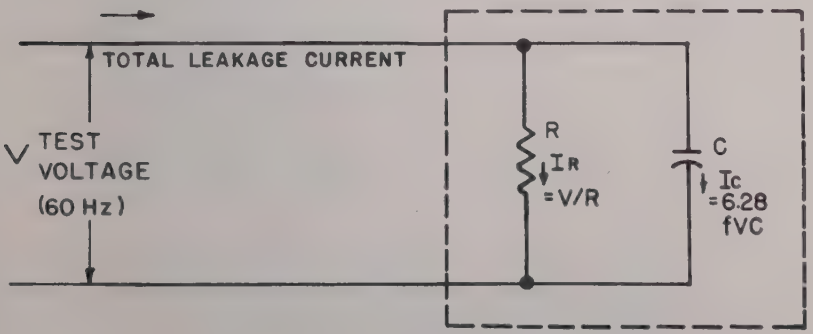
All electrical insulating structures, when subjected to voltage, conduct some current. When alternating voltage is applied, this current is made up of two components, one due to conduction through or across the surface of the insulator, (the resistive component) and one due to the capacitance of the structure (the capacitive component.) Both of these components are undesirable and are kept very small by design in new equipment. Nevertheless, some current of both types always "leaks" around or through any insulator; hence the name "leakage current". (Under some definitions, only the resistive component is called leakage, but we are following existing practice in including the capacitive component also.)

2.1 cont'd

Leakage current of both resistive and capacitive types increases with voltage, and generally also with size of equipment; capacitive current especially is high for items having windings (motors, transformers), or long runs of wire (wired control panels, etc). In good new equipment, the resistive component is usually much smaller than the capacitive component.

Do not confuse the leakage which occurs during a dielectric withstand test with the leakage which exists when an appliance is energized at its normal operating voltage and for which limits are specified by various safety standards, such as UL. This operating leakage is an important safety consideration, but is only indirectly related to the high pot leakage, and it is normally much smaller. It cannot be measured by any high pot tester. Ask about other Biddle instruments to measure this line-voltage leakage current.

The sketch below shows a schematic representation of the leakage current paths during an insulation test. In good equipment, I_R is usually much less than I_C.



2.2 Insulation Failure

When defective insulation is subjected to a high voltage, one of two things may happen:

a. Leakage current increases greatly because part of the insulation has become conductive.
b. A spark jumps across an air gap which has become too short.

Condition (1) may lead to (2), and (2) usually leads to a continuing "breakdown" discharge which emits light, heat, and a crackling sound, and carries as much current as the tester will deliver, causing the output voltage to drop to a low value. Such a discharge also causes high frequency (RF) variations in the current, which is useful in detection.

Some defects which cause failure are:

a. Dirt on the insulation causes increased resistive current; this may heat the surface and cause a further increase and may lead to a discharge. Moisture always aggravates this condition.
b. Cracks or pinholes in insulation usually lead to a quick breakdown and discharge.
c. Shortened air gap due to defective assembly may cause discharge across the gap. An example is a loose strand of wire near the frame.
d. Insulation saturated with moisture may cause a large increase in either component of leakage current.
e. A short circuit conducts a large current, but may not produce any immediately visible or audible effects.

3. How the Model 305 Works

3.1 Output

Figure 4, a graph of output voltage vs. capacitance, shows the general output characteristics of the Model 305.

The upper line shows the voltage that the tester can deliver with the Voltage Control at maximum, that is, the highest possible output. At lower settings of the Voltage Control, the voltage line drops proportionally; a line for a setting on the fifth division line is shown for illustration.

The peaks in these curves are due to resonance between the test item capacitance and the internal current-limiting inductance of the tester. As shown, such resonant peaks may go far above the 3000-volt rating of the set; this should not be permitted by the operator. If it is suspected that resonance may occur, the test voltage should always be started from zero and increased slowly while the voltmeter is observed for output voltage; this avoids overstressing the unit being tested.

Note that the tester can drive a capacitance of well over 5000 pF to its full rating of 3000 volts. Loads having high capacitance, however, cannot be driven to full voltage. For test items having capacitance outside the range of the 305, a larger tester must be used.

For convenient reference, Figure 4 includes a number of test items listed along the capacitance axis at their typical value of capacitance. This enables a quick estimate of whether any item listed or similar item can be energized to a specific voltage by the Model 305.

3.2 Automatic Failure Detection

The Model 305 has two failure-detection channels which sense the current supplied to the item under test. The first,or breakdown, channel is sensitive only to the high frequency (RF) signals generated by an arc or sparking failure; it is always in operation.

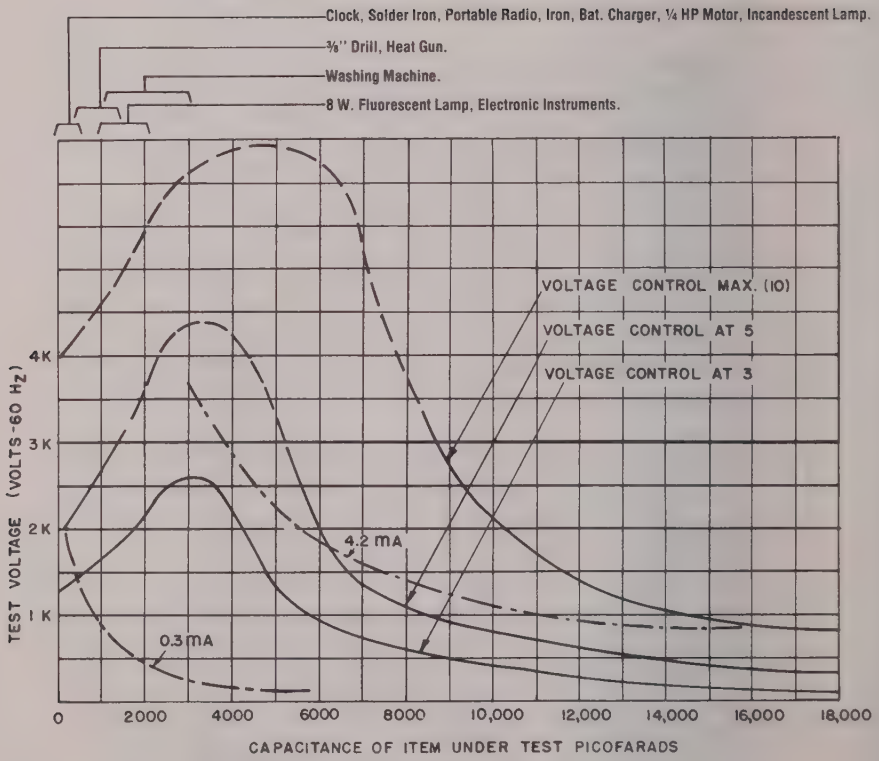


Figure 4: Typical Test Voltage vs. Load Capacitance, Showing Voltage Capability at any Capacitance, Useful Range of Leakage Test, and Capacitive Leakage of Typical Test Items.

The second, or leakage, channel is sensitive to all frequencies including the line frequency; it therefore detects leakage current and short circuits as well as arcing faults. It has an adjustable detection threshold covering a range of 0.3 mA to 4 mA; it can also be switched off. This channel is controlled by the Breakdown/Leakage control whose functions are shown in Figure 5.

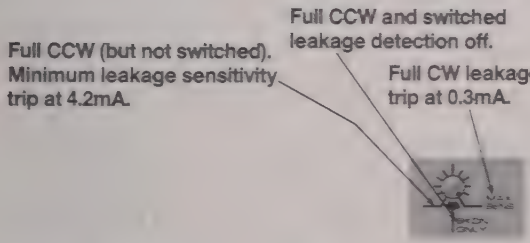

Full CCW and switched leakage detection off.
Full CCW (but not switched). Minimum leakage sensitivity trip at 4.2mA.
Full CW leakage trip at 0.3mA.

Figure 5: Detail of Leakage Breakdown Control, Showing Leakage Trip Functions at Key Positions.

Note that when both channels are in use (the usual case) they both contribute to detection of breakdown conditions.

The leakage trip range is shown on Figure 4 by two dotted lines representing the extreme settings. Any test whose V & C values fall to the left of the 0.3 mA line has a normal current less than 0.3 mA; thus the test can be made with the 0.3 mA (MAX. SENS.) trip setting. If the leakage rises above 0.3 mA, tripout will occur. Items whose normal V-C point falls anywhere to the left of the 4.2 mA line can be tested by setting the trip level to a value somewhat higher than the normal leakage expected. Items whose V-C point falls to the right of the 4.2 mA line cannot be tested for leakage current by the Model 305, since even normal units would cause a tripout.

The operator may occasionally detect a visible or audible discharge or erratic voltmeter indication, without an accompanying failure signal by the tester. These represent borderline cases in which the discharge energy remains small and does not build up to a full breakdown. If repeated during the test period, these should be taken as signs of failure. If a single snap occurs, not repeated, it may be taken as a stray projection which has burned off and the item under test may be accepted. Such weak pops seldom occur at higher test voltages and with high capacitance test items. However, some complex structures, such as relays and transformers, may emit a more or less continuous buzz at high voltage; this is very low energy "corona" discharge which should be ignored.

4. Setup for Breakdown Testing

4.1 General

Most test specifications call for detection of breakdown only; that is, they do not state a maximum allowable leakage current. Even for these tests, however, the tester should be used with leakage detector active, whenever possible as outlined in Section G-1. There are several reasons for this:

a. The tester will trip out on abnormal high currents, which provides shock protection for the operator and limits possible damage to the items under test.
b. The additional check for abnormal leakage current is a good product quality check; comparing the leakage of the item to that of normal like items.
c. The tester gives an automatic failure alarm on a short circuit item. (In the breakdown only mode, it gives no alarm, although the voltmeter clearly shows the condition.)
d. The tester will be more sensitive to small borderline non-sustained discharges (not quite a true breakdown) which the breakdown channel alone might miss.

4.2 Low-Capacitance Items
Figure 4 shows that most test items have a capacitance well below 1000 pF which implies a leakage current less than 0.3 mA when tested at 1000 to 1200 volts. In such cases the tester can and should be always used with the B/L control at MAX SENS.

4.3 Medium-Capacitance Items
Medium-size test items, having capacitance up to about 5000 pF, can be tested with the L/B control at some intermediate position. This range of tests falls between the dotted lines on Figure 4.

4.4 High-Capacitance Items in BKDN ONLY Mode; Voltmeter Interpretation
The L/B control should be switched to BKDN ONLY only when testing items whose normal leakage current is above the 4.2 mA maximum of the leakage trip circuit. As previously mentioned, this is quite unusual.

Although the tester will not trip out on leakage current, the operator can detect variations from an established normal leakage for a given product by observing the normal position of the voltage control dial which produces the specified test voltage. Any change in this pattern indicates abnormal leakage in the product being tested. Resistive leakage causes a low voltmeter reading. Added capacitance leakage also normally causes a low reading. (However, if this method is used with items having capacitance below the resonance peak, adding capacitance will reduce the reading, as can be seen from Figure 4).

Voltmeter readings will also vary with the line voltage; however, such variations can be eliminated by operating from a regulated line.

4.5 Excessively High-Capacitance Items Not Testable
If the capacitance of the test item is so large that its C-V point falls beyond the maximum output line in Figure 4, it is too large for the Model 305 to handle. This will be clear when attempting to test, since even on a good item the voltage will not reach the desired setting when the voltage control is turned to maximum.

5. Setup for Leakage Testing
When a leakage test is specified, the maximum allowable current will normally be stated. The L/B control must be set to trip at this current value. To make this setting, proceed as follows:

1. Connect an AC milliammeter having a range of 0-5 or 0-10 mA across the output of the tester. (A Biddle AVO 8 or AVO EM272 is recommended.)

2. Slowly raise the output voltage control, and note the milliammeter reading at which the tester alarms.

3. Readjust the leakage level control (clockwise decreases the trip level) and repeat the test. By trial and error, set the trip current level to the desired value. Alternately, if a milliammeter is not readily available, use a known resistance load and divide the voltmeter reading by the resistance to obtain the actual current value.

6. Failure Analysis with the Model 305
The Model 305 can be helpful in trouble-shooting during design and repair, as well as in straight product testing. To locate weak spots in a test item, the following procedures may be used.

To find breakdown level and location, set the L/B control to BKDN ONLY and raise the voltage slowly, watching the voltmeter. If a breakdown trip occurs, reset the Voltage control and again raise it. Approach the breakdown value slowly watching the item under test for the location of the spark jump.

5. cont'd.

To measure leakage, the simplest method is to measure the current at any voltage, using an AC milliammeter as mentioned in sub-section 5. A suggested procedure is as follows:

- Clear any breakdowns in the voltage range of interest.
- Connect milliammeter to black lead, and test item between red lead and milliammeter.
- Set L/B control to BKDN ONLY.
- Set voltage and read V and I.

If a milliammeter is not available, the leakage trip feature of the tester can be used to compare one test item to others. With the L/B control at minimum sensitivity, set the desired voltage. Then turn the L/B control CW, noting the point at which alarm occurs for the suspect item and the standard. The dial calibration is non-linear, but the comparison gives an indication of relative leakage amounts. A definite calibration of the dial can be made by testing resistors of various known values in this way. At 500 volts, 2-watt carbon resistors can be used, giving for example, the following leakage reference points:

1.0 megohms, trip at 0.5 mA
560 K ohms, trip at 0.9 mA
270 K ohms, trip at 1.8 mA
180 K ohms, trip at 2.8 mA

Section H

TESTING TO UNDERWRITERS LABORATORIES STANDARDS

GENERAL

UL Standards for electrical equipment generally require that a new design be given a "Dielectric Withstand" test; and for many classes of equipment, the Standards require a 100% production-line test as well. The standards also define certain requirements for the test equipment used. The Model 305 High Pot Tester meets the requirements for production-line tests.

TYPICAL UL STANDARDS

As a typical example of these requirements, UL1004 "Electric Motors". as revised 3/1/74, states as follows:

" 20.1 Each motor shall wishstand without breakdown, as a regular production-line test, the application of a 60-Hz test potential as described in paragraphs 20.2-20.4.

20.2 ...the potential is to be applied for one minute...The time of application of the potential may be reduced to 1 second if the value of the test potential is 120 percent of the value specified for the one-minute test.

20.3 ...The voltage...is essentially sinusoidal and can be varied. The applied potential may be started at zero, is to be increased gradually until the required test value is reached, and is to be held at that value for the specified time.

20.4 The test equipment is to include a visible indication of application of the test potential and an indication of breakdown that is audible or visible or both. In the event of breakdown, manual reset of an external switch is to be required or an automatic reject of the unit under test is to result; other arrangements may be considered and accepted if found to achieve the results contemplated. A 500-volt-ampere or larger-capacity transformer need not be used in tests by the manufacturer if the transformer is provided with a suitable voltmeter to measure directly the applied output potential."

TESTING TO UNDERWRITERS LABORATORIES STANDARDS

As another example, UL45, "Portable Electric Tools", of 15 July 1974 calls for essentially the same production line test, in section 44.1, but does not make any requirement on the test equipment itself.

Standard UL73, "Motor Operated Appliances", covers many domestic and commercial appliances. A 100% production-line test was added in the revision of June 21, 1974. It is more detailed than the two others mentioned. Significant provisions are noted below:

"26A.1 Each appliance shall withstand without breakdown, as a routine production-line test, the application of a 40-70 Hz potential...

26A.3 The test potential..shall be applied for 1 second except that the test potential may be reduced to 5/6 of the values shown if the time is increased to 1 minute.

26A.7 The test equipment shall include a transformer having an essentially sinusoidal adequate output.

26A.8 If the output of the test equipment transformer is less than 500 volt-amperes the equipment shall include a voltmeter in the output circuit to directly indicate the test potential, and an audible or visual indication of breakdown. In the event of breakdown, manual reset of an external switch is required or an automatic reject of the unit under test is to result.

26A.10 Test equipment other than that described...may be used if found suitable to accomplish the intended factory control."

The voltage specified in these tests varies with equipment size and rating but falls between 900 and 2500 volts,except that in UL73 an appliance "that is applied in a wet or moist condition directly to persons" requires 3000 volts.

Standard UL492, "Radio and Television Receiving Appliances" as of May, 1973, calls for a routine production test at 1080 volts for one second. Further, the test equipment is to include a visible indication of the application of the test potential and an audible and/or visible indication of breakdown. In the event of breakdown, manual reset of

an external switch is to be required or an automatic reject of the unit under test is to result.

"LEAKAGE" SPECIFICATIONS

The "leakage current" mentioned in some more recent UL Standards is not the same as the leakage tested by the Model 305 (or any other dielectric withstand tester that we know of.) This "leakage current" must be measured at normal operating voltage, as discussed in Section G. Typical UL standards do not require a leakage check during withstand testing.

SUMMARY OF TESTER REQUIREMENTS

Based on these examples and others, the key requirements for the routine test equipment are listed below (all of which are met by the Model 305 High-Pot Tester).

1. Transformer supply, variable, with sinusoidal waveform. The Model 305 High-Pot tester has all of these features.

2. 500 VA capacity, or lower capacity with directly connected voltmeter. The Model 305 High-Pot tester uses a low-capacity transformer to avoid serious shock hazard. The voltmeter is connected directly across the output, as required.

3. Visible indication of application of test potential. Model 305 High-Pot tester has both a lamp and the voltmeter indication.

4. Audible or visible indication of breakdown (or both, in some standards). The Model 305 High-Pot tester has both a lamp and a buzzer.

5. Manual reset after breakdown by an external switch. The Model 305 High-Pot tester has this feature built into the voltage control knob.

TESTING TO UNDERWRITERS LABORATORIES STANDARDS

TYPE TESTING

The Model 305 High-Pot tester is equally well suited for the evaluation (or "Type" or "Performance") tests which are usually specified separately in UL Standards. Although some of the standards require a 500 volt-ampere tester, others (for example, #942 Radio and Television, and #507 Electric Fans) do not. A tester capable of 500 volt-ampere output would deliver a current of 1/2 ampere at 1000 volts, which is extremely hazardous. For personnel safety, the James G. Biddle Co. recommends that the Model 305 High Pot tester be used for these tests on all equipment within its capacity. We have discussed this with UL engineers and are sure that evaluation tests made using the High-Pot tester will give the same results as those made by UL on approval testing. As long as the voltmeter indicates the desired voltage, the test is valid.

Section I

ROUTINE MAINTENANCE

GENERAL

Certain routine checks are necessary to insure safe and correct function of the tester. These checks are described below. No other routine maintenance is required.

Make all the following checks after repairs and at regular scheduled intervals, at least once a year; more often if the set is in heavy use.

FUNCTIONAL CHECK

Make all the tests of Table 1 in Section F. Make the Leakage Trip Test twice, once with the control at MAX SENS and once at minimum sensitivity, that is, at the counter-clockwise position but not switched to BKDN ONLY. Repair the set if all tests are not passed.

GROUND CIRCUIT RESISTANCE

Measure the resistance between the ground pin of the line plug and the ground (black) output lead, using a bridge or meter having 0.1 ohm sensitivity. The normal reading is 0.25 ohms. If greater than 0.5 ohm, repair.

MECHANICAL INSPECTION

Clean case, panel, leads, and line cord to remove any possible conducting residues. Use water and soap.

Inspect at the following points, and repair as needed.

1. Case and panel sound and free of cracks, screws holding fast.

2. Output leads free of visible cracks. Probes and clips complete and insulation sound. Leads firmly clamped at panel.

3. Line cord firmly clamped; insulation sound.

ROUTINE MAINTENANCE

VOLTMETER CALIBRATION

This procedure requires a voltmeter of known accuracy with a range of 3000 volts rms, such as the Biddle AVO Model 8 Multimeter.

1. Remove the four panel screws and lift the test set from its case; stand the test set with the panel vertical.

2. Connect the standard voltmeter to the output leads of the test set as shown in Figure 6.

> CAUTION
>
> Take care not to touch the exposed high-voltage terminals located beneath the shield of the uncased instrument.

3. Energize the test set and rotate the voltage control clockwise until the standard voltmeter reads 3000 volts.

4. Observe the test set voltmeter. If its reading coincides with the standard voltmeter reading, no adjustment is required.

   NOTE: If no adjustment is required, omit steps 5 and 6; proceed to step 7.

5. If the voltmeters do not agree, adjust the test set voltmeter by turning the trimming resistor (R3) located on the instrument printed circuit board. (The location of this resistor is shown in Figure 6.)

6. When the full scale readings of the standard voltmeter and the test set voltmeter are in agreement, the voltage control can be used to check all cardinal points of the voltmeter scale.

7. After the voltmeter has been calibrated, replace the test set in its case and replace the four panel screws.

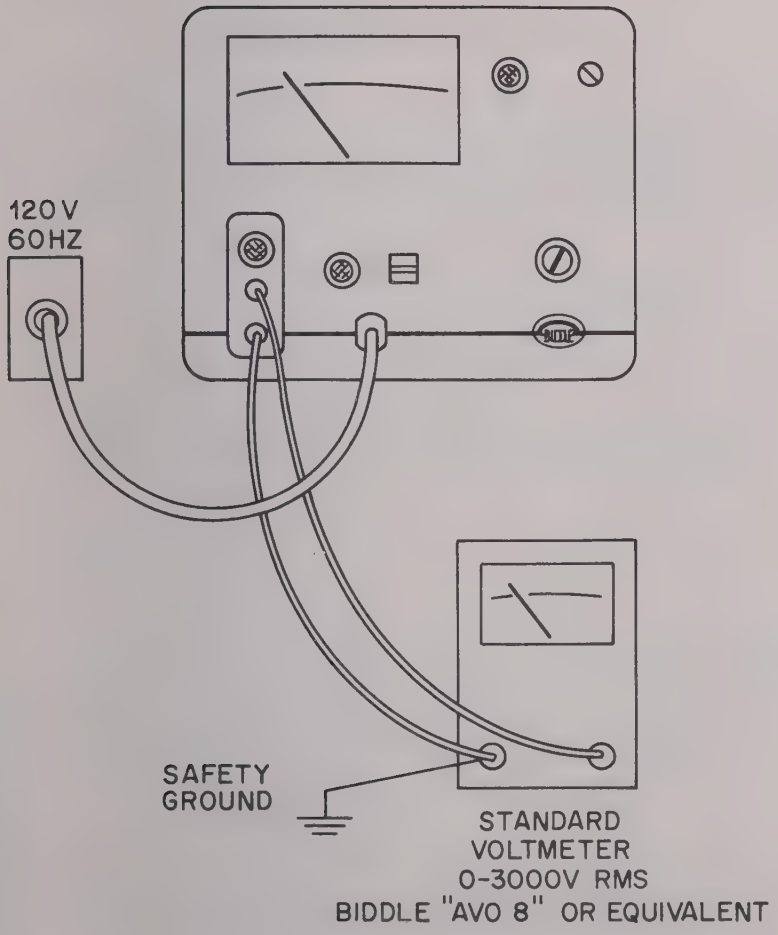


Figure 6: Connections for Calibration of Voltmeter.

ROUTINE MAINTENANCE

LEAKAGE TRIP RANGE CHECK

Use an AC milliammeter with resolution to 0.1 mA, such as the Biddle AVO-8 or EM272 multimeter. Connect the meter across the tester output and proceed as follows:

1. Turn tester on and set Voltage control to zero.

2. Set L/B control to MAX SENS.

3. Slowly raise the Voltage control. The tester shall alarm at a reading of 0.3 $\pm$0.1 mA.

4. Repeat steps 1-3 with L/B control turned full CCW, but not switched to BKDN ONLY. The tester shall alarm at a reading of 4.2 $\pm$0.4 mA.

Section J

TROUBLESHOOTING AND REPAIRS

CAUTION:	To retain the safety features of the tester, use only Biddle factory parts for replacement of test leads, high voltage transformer, case, panel, and mechanical parts.

GENERAL

Persons repairing the test set must understand the operation of the circuitry in order to appreciate safety precautions to be taken. The circuitry is explained in the following sub-section.

Certain repair procedures are described in further sub-sections. If parts must be ordered from the factory, always mention the serial number (located as shown in Figure 2).

After repairs, always make the safety and operation checks of Section I. The final part of this Section is a guide to trouble-shooting.

CIRCUIT DESCRIPTION

The electrical operation of the test set is described below and illustrated in the schematic diagram provided in Figure 9.

The primary winding of the high-voltage transformer (T2) is connected to an adjustable autotransformer (T1) which determines the transformer primary voltage and, in turn, the secondary or output voltage. T1 is energized through a self-latching relay (K1). When the relay is energized and latched, voltage is supplied to the transformer primary and to the high-voltage indicator lamp (DS2). If the voltage control is turned clockwise, the voltmeter (M1) will indicate the increasing voltage which is present at the output cable test leads.

When the relay isn't energized, no voltage will be supplied to the auto-transformer (i.e., there will be no high-voltage output): but the failure lamp (DS3) and the audible alarm will be energized. Note the high-voltage lamp and failure lamp can never be lighted simultaneously.

When breakdown or current in excess of the leakage level setting occurs in the test loop, the electro-optical fault detector (V1) will sense the condition and cause relay (K1) to be de-energized. This cancels the high-voltage output and activates both the visual and audible failure indicators. High-voltage output cannot be restored until

the voltage control is returned to the RESET position. This closes the zero-start contact (E1) which energizes K1 and lights the high-voltage indicator lamp (DS2); the test set is again responsive to the voltage control.

NOTE: Test sets which are fitted with the optional reset pushbutton operate exactly as described above. In addition, relay K1 can be energized by pressing the reset button (S3) at any voltage control setting.

REPLACEMENT OF POWER LINE FUSE

The test set contains a 2.0 Amp AGC fuse located on the interior chassis/shield. (See Fig. 7.) If this fuse is defective, the test set will not operate. To replace the fuse, follow the procedure given below.

1. Remove the four panel screws and lift the test set from its case; stand the set with the panel vertical.

2. Remove the fuse from the fuse holder.

3. Install the proper replacement fuse. (See Section K.)

4. Replace test set in its case, replace the four panel screws.

   NOTE: High-Pot Testers equipped for 240-V 50/60 Hz operation contain two additional fuses to protect each side of the 240-V power line. (See Figure 8.) To replace these fuses, follow the procedure given above.

REPLACEMENT OF TEST LEADS

The original output test leads supplied with the test set may be replaced with longer leads or leads with different types of terminations. Only the Biddle replacement leads are recommended for use with the High-Pot Tester. The high voltage lead wire and fittings of these leads are of excellent quality, and each set of leads is tested for high voltage integrity at 15 kV.

1. Remove the three screws holding the red CAUTION plate in place.

2. Pull the lead connectors from their jacks.

3. Insert the plugs of the replacement leads into their respective jacks (red and black).

4. Install the retaining plate over the insulation of the plugs and work the plate down until it is flat against the panel.

5. Replace the three screws and tighten carefully.

Adjustment of Zero-Start Switch

After a long period of use, the action of the zero-start switch may become erratic or the switch may fail to operate. To adjust the switch, follow the procedure given below. (Figure 7 shows the location of the zero-start switch.)

NOTE: The test set must be de-energized during this adjustment procedure.

1. Remove the four panel screws and lift the test set from its case; stand the test set with the panel vertical so that the rear of the instrument can be viewed.

2. Rotate the voltage control knob and observe the action of the zero start switch. When the voltage control is rotated to the RESET position, the blade of the zero start switch should make light contact with the wiper arm of the autotransformer.

3. To adjust, carefully bend the blade of the zero start switch to ensure correct switch action. A continuity meter may be used to verify proper contact between the wiper arm and the blade of the zero-start switch.

4. Replace the test set in its case and replace the four panel screws.

TROUBLESHOOTING

Use the test procedures of Sections F and I to determine the failure symptoms. Use the Troubleshooting Guide, Table II, and the Circuit Description paragraph to determine from these symptoms which component has failed.

TABLE II. TROUBLESHOOTING GUIDE

MALFUNCTION	POSSIBLE CAUSE
POWER ON lamp fails to light. Output voltage present.	Defective POWER ON lamp.
POWER ON lamp fails to light. No output voltage.	Fuse blown. Defective service outlet. Defective line cord. Defective power switch.
Failure lamp and buzzer energized when power switch turned ON. Failure indications continue when voltage control turned to Zero.	Zero start switch not making proper contact. Adjustment required.
Failure indications occur when voltage control moved from Zero (with output leads open-circuited).	Self-latching contact of K1 not making contact. Resistor R6 open. Internal short in test loop.
Meter reads zero when voltage control advanced. No output voltage. POWER ON and HIGH VOLTAGE lamps lighted. Failure indications may occur.	High-voltage circuits shorted internally. High-voltage probe contacting grounded object.
Meter reads zero when voltage control advanced. Output voltage present.	Defective meter.
No failure indications when voltage control is advanced (with output leads connected to each other, leakage/breakdown control set to MAX. SENS).	Opto-isolator (P1) defective. Resistor R8 open. Resistor R9 open. Resistor R5 open. Capacitor C1 shorted.

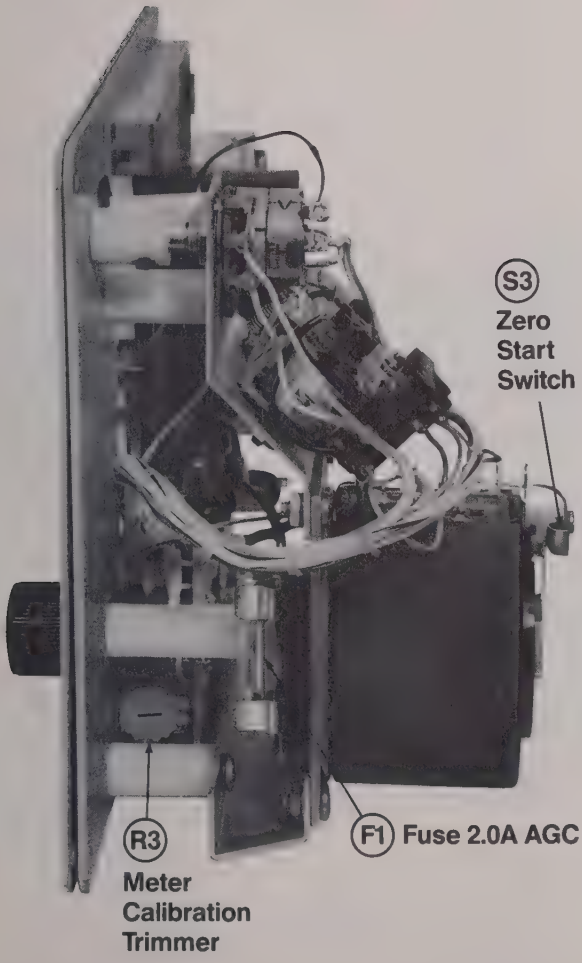


Figure 7: Internal View of Test Set Showing Fuse and Trimmer Locations.

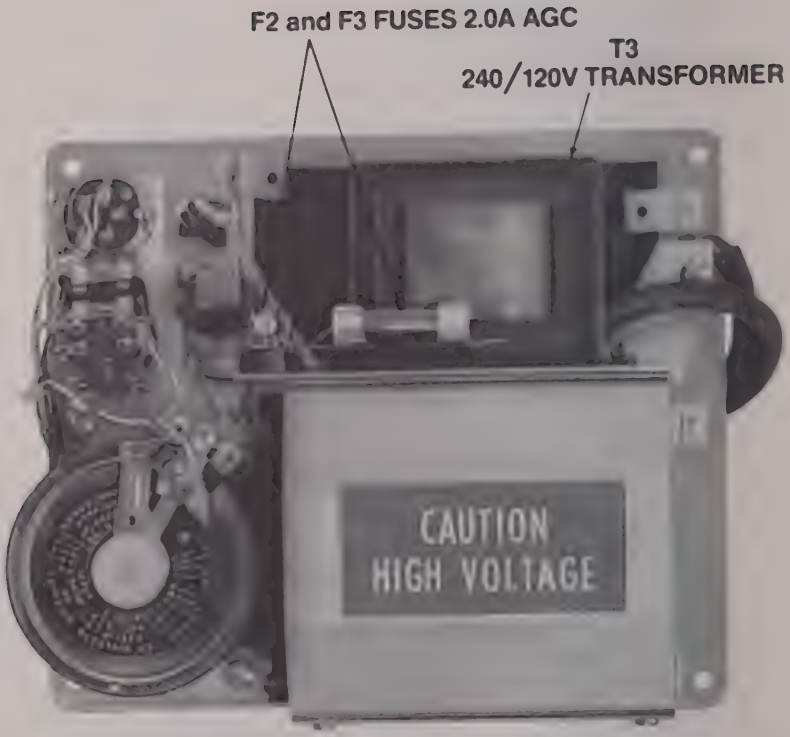


Figure 8: Inside Rear View of High-Pot Tester, Model 305-1 (240V 50/60 Hz Version).

Section K

PARTS LIST

SYMBOL	DESCRIPTION	JGB PART NO.
Resistors:		
R1	1MΩ 1/2W, 1%	4502-1 (3)
R2	301Ω 1/2W, 1%	11445-3
R3	1KΩ Trimmer	5183-2
R5	250KΩ Potentiometer with SPDT Switch	14880
R6	51KΩ 1/2W, 5%	4501-108
† R6	33KΩ 1/2W, 5%	4501-186
R8	3.9KΩ 1/2W, 5%	4501-157
R9	12KΩ 1/2W, 5%	4501-101
R10	1KΩ 1/2W, 5%	4501-147
† R10	10KΩ 1/2W, 5%	4501-124
R10a	5KΩ 1/2W, 5%	4501-137**
R11	50KΩ 1W, 5%	4501-419**
Capacitors:		
C1	0.002 µF, 20%	7950-5
C3	1200 pF, 10kV	15739-1**
Diodes:		
CR1, CR2	IN4004	11637-34
† CR1, CR2, CR3	IN4004	11637-34
† CR4	IN4763	12074-32
Switches:		
S1	Switch SPDT	14870
S2	Part of 14880	
S3	Pushswitch	5431*
E3	Leaf Contact	14869
Miscellaneous:		
	Plastic Case	11990-1
	Lid with Storage Compartment	13335-1
M1	AC Voltmeter	14861
T1	Variable Transformer	6408
T2	High-Voltage Transformer	14850
T3	220/120V Autotransformer for Cat. Nos. 230305-1, 230405-1	14864***
D4	Buzzer	14860
K1	Relay	14924
DS1	Pilot Lamp	4499-1
DS2, DS3	Failure and High-Voltage Lamps	4499-2
	Fuse Holder	9745-1

PARTS LIST

SYMBOL	DESCRIPTION	JGB PART NO.
F1, F2, F3	Fuse, 2.0A, 250V, Type AGC	2567-5
	Test Leads with plate, probe, clips	14874
P1	Opto-Isolator	14865-1
	Retainer Plate	14859-1
	Banana Plug (red)	6610-1
	Banana Plug (black)	6610-2
	Probe	14863-1
	Bulldog Clip (red)	14862-1
	Bulldog Clip (black)	14862-2
	Knob, Voltage Control	14877
	Line Cord (Cat. No. 230305 only)	14879
	240V male plug (Cat. No. 230305-1)	14873***
L1	RF Choke	14871

* Models with pushbutton reset only.
** 4 kV outputs only.
*** 240 V 60 Hz input only.

NOTE: All parts preceded by the symbol "†" are used in instruments with serial numbers above 4294. Conversely, all parts without the symbol "†" are used in instruments with serial numbers below 4294. Also see Figure 9A for serial numbers 3600-3699.

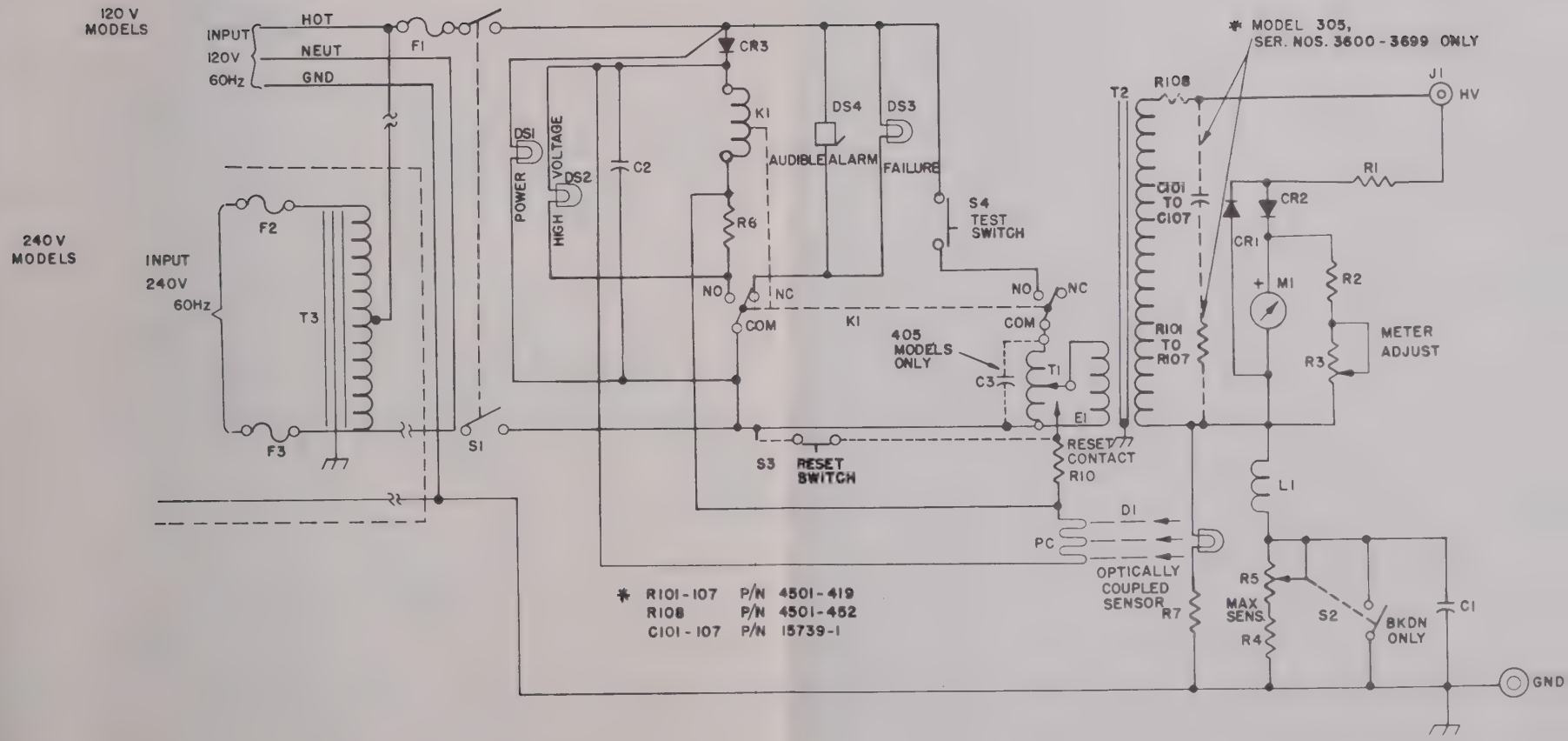


Figure 9: High-Pot Tester Schematic Diagram for instruments having serial numbers above 4294.

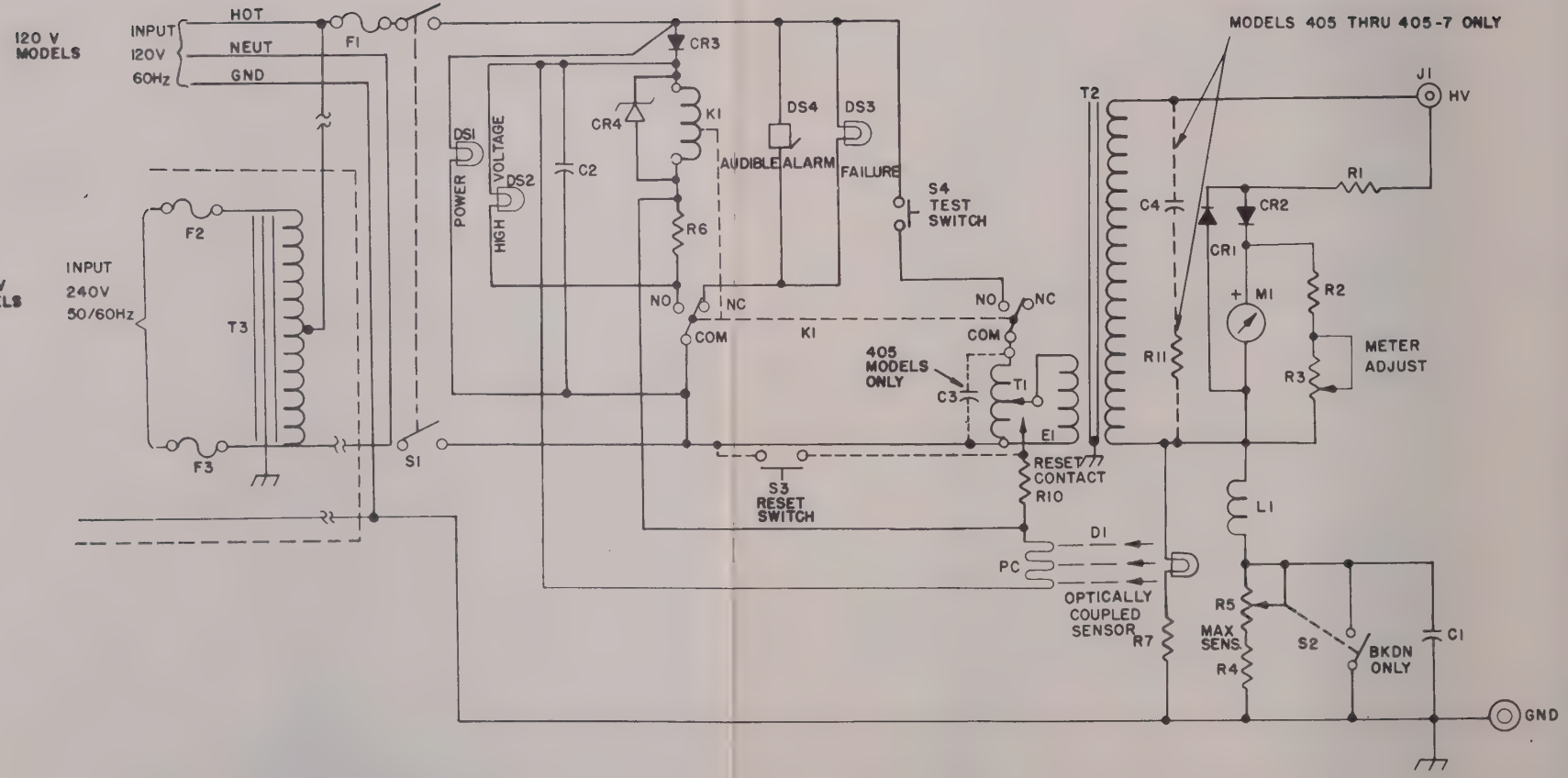


Figure 9A: High-Pot Tester Schematic Diagram for instruments having serial numbers below 4294.

Section L

WARRANTY AND REPAIRS

WARRANTY

All products supplied by the James G. Biddle Co. are warranted against all defects in material and workmanship for a period of one year following shipment. Our liability is specifically limited to replacing or repairing, at our option, defective equipment. Equipment returned to the factory for repair will be shipped Prepaid and Insured. The warranty does not include batteries, lamps or tubes, where the original manufacturer's warranty shall apply. WE MAKE NO OTHER WARRANTY.

The warranty is void in the event of abuse or failure by the customer to perform specified maintenance as indicated in the manual.

REPAIRS

The James G. Biddle Co. maintains a complete instrument repair service. Should this instrument ever require repairs, we recommend that it be returned to the factory for repair by our instrument specialists. When returning instruments for repairs, either in or out of warranty, they should be shipped Prepaid and Insured, and marked for the attention of the Instrument Service Manager.

MP MASTER
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James G. Biddle Co.

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